

# Tales of contract enforcement in transition

Yulia Kossykh and Andrei Sarychev

3 December, 2000

## Abstract

We tackle, arguably, the central issue in transition - developing contract enforcement institutions. In the world of thin markets and immature legal systems, market failure arises due to contracting problems. Reputation mechanisms may alleviate such problems in static environments, but may not be fully effective in evolving, out-of-steady-state transition economies. Building on insights from modern law economics corroborated by recent evidence, we propose a dynamic theory of adjustment of these mechanisms.

We model an economy with no public system of contract enforcement, where restructuring increases both productivity and exposure to hold-up. The fundamental transition conundrum is how to make firms restructure, if the degree of restructuring is unobservable. We show that there exists a decentralized adjustment path along which firms restructure continuously, while signaling that they proceed at the common pace. As the second part of the paper argues, in transition, existing networks are expected to be eventually replaced by new networks of restructured firms. This shortens the effective horizons of the agents and spoils the calcula-

tion of strategic benefits of cooperative behavior, resulting in a period of relatively primitive economic activity.

Thus, in the aftermath of transition, new contracts are excessively simple to economize on enforcement. The new social mechanisms for preventing violations of contracts take time to develop and will naturally crystallize when restructuring is complete.

## 1 Introduction

The problem of contract enforcement is widely acknowledged as a primary issue in transition of formerly planned economies. The common view is that historically, these countries have relied on state to enforce dealings among state-owned enterprises. Once the economies became decentralized and privatized, there was no mechanism in place to enforce those new agreements. Inherited legal systems were universally viewed as inadequate for market economies. Many scholars concluded that a speedier upgrading of law enforcement institutions is the most crucial ingredient of the transition success.

Law economists, however, have long argued that legal systems in themselves may be capable of enforcing only a minority of contracts in an economy. As Rapaczynski [1996] noted, legal system can solve only marginal cases. Consequently, there must be other mechanisms in place that support most of the contracts. They must be based not on the formal enforcement but rather on strategic calculations of future reward associated with honoring contractual agreements.

Enforcement is so central to the success of transition because industrial organization is endogenous and determined by institutions. Modern growth is associated with high

degree of specialization and investment in specific assets. Whenever production requires specific assets, however, there is room for hold-up. Unless there are ways to make their partners precommit to terms of contract, firms will prefer not to make those investments and gear their production structure toward more primitive contracts. In extreme cases they may resort to barter. Thus, the absence of contract enforcement may lead to selection into less efficient contracts, and put a ceiling on aggregate productivity, the possibility highlighted by Blanchard and Kremer [1997]. Arguably, this is what happened in Eastern Europe, and was most pronounced in Ukraine and Russia. Johnson, McMillan and Woodruff [1999] provide survey evidence that in transition economies it is indeed the insecure contractual environment that hinders investment, not the lack of outside finance. This leads to a question, will these economies ever succeed in curing the problem? Can informal mechanisms successfully substitute for formal enforcement? Can this happen in a decentralized equilibrium? What are the features of the adjustment process? This paper strives to provide a theory of the evolution of enforcement institutions that is both micro-based and explicit about the particular incentive mechanism involved.

The issue of contract enforcement is not unique to transition economies. Even in mature market economies, contracts are maintained *both* by invoking law and informal mechanisms (Macaulay [1963], Ellickson [1991], Arrighetti, Bachman and Deakin [1997]). Relational contracting, or bilateral reputation, is the most frequently cited variety of such informal mechanisms. Contracting parties expect their partnership to last for a long time and therefore prefer not to renege on agreements. Ghosh and Ray [1996] study equilibria in community interaction where bilateral punishment is the only form of sanctioning available and the reputation needs to be built up. Cooperation arises gradually, as firms

learn from experience about partner's reliability.

This type of contracting has a disadvantage of being biased toward established relationships as firms hesitate to try new partners. A superior alternative is offered by coalitions of firms sanctioning deviations from contracts by boycotts. Greif [1993] recounts an illuminating story of the use of multilateral punishment strategies (MPS) by medieval merchants in Mediterranean. Agents did not cheat on their masters because they anticipated a boycott by other merchants in case of misconduct. Coalition thus served as a credible mechanism for punishing breach of contract. Greif shows that MPS is in general more effective in sanctioning breach than pure relational contracting. Moreover, MPS does not rely on established history of trading and therefore allows contracting between total strangers. This removes barriers to entry/signing new contracts, present under relational contracting.

The transition economies present a natural experiment in the evolution of MPS. There is no public system of contract enforcement in place because it was not needed before the liberalization. Courts lack expertise and resources to do their job [Pistor, 1996], while most firms are unaware of or misunderstand new laws [Hendley, Ickes, Murrell and Ryterman, 1997]. If economic growth is to resume, firms must start making specific investments, and therefore, find means to enforce complex contracts. Meanwhile, in a 1996 survey of Russian firms, Hendley et al. [1997] found little evidence that enterprises buy or sell sophisticated complex goods. Only one contractual agreement in their entire survey was reported as requiring special investment.

This is to be expected, since networks and relationships inherited from the past are organized around an extremely inefficient model of production, and therefore should be

eventually dismantled and replaced by new relationships and networks. Before the new relationships and networks form, most of the production in the economy will remain primitive.

Indeed, quoting Johnson, McMillan and Woodruff [2000b], “simplest transactions in markets involve the sale of standardized goods made for inventory and sold for cash. As markets develop, producers make more customer-specific goods.” In the five countries in Johnson et al.’s [2000b] survey, specialized goods were likely to be produced for recently added customers (new partners). Russia and Ukraine produce substantially fewer specialized goods than firms in Poland, Slovakia, and Romania (consistent with the data on the relative severity of contracting problems in the former).

The above evidence on specialization of production in transition, together with the examples of the use of group sanctions in the market economies, suggest that MPS is crucial for the resurgence of growth in transition countries.

If that is the case, transition countries seem to be moving in the right direction. Recanatini and Ryterman [2000] document the emergence of new business networks in Russia. Hendley, Murrell and Ryterman [1999] present evidence that reporting instances of contract violations to other firms was used by 47.56% firms in their sample. Johnson, McMillan and Woodruff [1999] and Johnson, McMillan and Woodruff [2000a] report statistical evidence from a recent survey of enterprise managers in 5 transition countries which show that membership in business and social networks plays a significant role in decisions to extend trade credit and commence new productive relationships.

All this suggests that informal coalitions play a role in enforcing contracts and it is therefore important to understand their evolution. The existing models of relational con-

tracting/MPS are essentially static. Ghosh and Ray's [1996] analysis is limited to stationary equilibria with replacement (so there is no change in the proportions of myopic/non-myopic types), nor does the nature of types change over time. Greif [1993] also sidesteps the issue of coalition formation. In his model, the coalition is already in the steady state.

The innovation of our research is to study this enforcement mechanism out of steady state. Our first model focuses on the aspect of restructuring that is entirely overlooked in the literature: the need to establish common knowledge that all members of the coalition have restructured. Restructuring increases productivity of firms if they play cooperative strategies. However, it also increases exposure of unsuspecting firms to expropriation and hold-up. Firms have an option of dealing in less productive contracts that also limit their hold-up exposure.

There exists a steady state in which all firms are finally fully restructured *and* this fact is common knowledge, so a simple collective punishment strategy can enforce highly productive contracts. However, if the degree of restructuring is unobservable to outsiders, it is not clear whether an economy could get into that steady state at all. An additional question is whether an economy would be able to do this on its own, with no intervention of a social planner to coordinate the restructuring effort.

The second part of our paper highlights the role of another aspect of informal collective enforcement: limitations of liability. We model a situation in which initially firms are members of a coalition that enforces deals between them. When restructuring starts, this coalition unravels, as the effective horizon of firms is reduced. At the same time, there is no coalition able to enforce "mixed" contracts between newly restructured firms and old firms. Consequently, the new entities also resort to the primitive contracts which are

impossible to renege on. While this is individually optimal for the firms, society bears an opportunity cost in the form of more elaborate and socially profitable contracts that are not implemented. It takes time for the proportion of restructured firms in the economy to reach the level when they can form a new coalition allowing them to enter into superior specialized contracts.

The roadmap for the paper is as follows. Section 2 contains motivation for the modeling assumptions of our theory, and some terminological conventions. Sections 3 and 4 present our models. Section 5 concludes. The appendix contains a few formal proofs.

## 2 Specialized contracts, hold-up, and restructuring

We start our discussion of hold-up in contracting with a stylized example which shares the view of the modern economy outlined in [Kremer, 1993].

Consider aircraft manufacture<sup>1</sup>. Aircraft are very complex, and their performance (and hence, the price they command in the market) depends on a huge number of components. For simplicity, assume the aircraft consists of a body and hydraulics that drives complex steering system. For best performance, the steering system should conform closely to general aerodynamic characteristics. To appropriate Kremer's example, every o-ring and every single bushing is important. Minor adjustments to design may yield dramatic improvements. Consequently, it is important that engineers of both companies learn a lot about their partner's technology to implement such adjustments. Thus, to produce a good airplane, manufacturer of the body and that of hydraulics must each make specific

---

<sup>1</sup>We thank Andrei Bogdzevitch, a graduate of Baumann Technical University in Moscow, for his help with this example.

investments. They are specific because the minute details of design are not shared by different aircraft and different hydraulics.

Suppose the two companies have agreed on a joint production plan. However perfect the legal system is, with the highly sophisticated technology such as this, it is impossible to make the specific investments part of a legally binding contract, due to large agency costs. Such investment will be a matter of good faith among the contracting parties. Consequently, they may have incentives to hold up each other *ex post*. Suppose, the hydraulics firm has done its part and came up with an exemplary design, having spent huge resources on research and development. However, the aircraft body company reneged on the agreement and did not make any specific investment. The plane being more than a mere sum of its components, it has poor fuel economy and maneuverability. Hence, it sells at a low price<sup>2</sup>. The specific investment made by hydraulic engineers is by now sunk, they cannot sell it anywhere else at a respectable price. They are forced to share in the meager realized profits. The net value of the project to them is negative, precisely due to that investment. The body manufacturer, on the other hand, enjoys a windfall, since no costly investment has been made. Only if both firms adhere to their commitments, the quality of the plane is outstanding, and the *ex ante* investments are profitable.

The two firms could have also decided on a less ambitious project (an agricultural plane instead of a supersonic transatlantic carrier). This would require very little specific investment and consequently, less threat of hold-up. Of course, there is a whole spectrum of technology choices (all sorts of training, cargo, and commercial aircraft) ranked by the

---

<sup>2</sup>In [Economist, 2000], a military analyst Pavel Felgenhauer is quoted as saying “Russian aircraft design is excellent, but engine reliability is less so. As in the rest of Russian industry, quality control can be patchy. What Russia sells is quite often actually lemons”.



complexity of their design and required specialization.

It may seem that an easy solution to the contracting problem is the integration of both firms into one. In the dynamic Shumpeterian world this is not a solution, however, and nor is bilateral reputation. After the aircraft project is completed, the hydraulics firm may get orders for a submarine, construction excavator, or auto power steering. That is why it is important to make distinction between relationship-specific investment and general investment. By installing modern equipment, hiring employees with degrees in hydraulic engineering and skillful managers, acquiring technological expertise, the hydraulics company may be able to produce better and cheaper products for any market and purpose. The general and specific investments are complementary for individual projects. Clearly, today's aircraft are better than in the 50s not because 50s experienced particularly severe contracting problems, but because a lot has been learned about technology, and new generation of equipment is available. That in turn allows dramatic improvements in specific designs.

The features of production outlined in this subsection are common to all countries, industrialized and developing. World technical progress is but the path of investment in general-purpose technologies (broadly interpreted). Transition economies face a particularly steep upgrade path, given the notorious inefficiencies in labor allocation, physical capital, management, use of technological expertise, etc.

In the remainder of the paper, we adopt terminology that reflects more transition realities. We label the general investment as “restructuring”. We emphasize the broad meaning of this word. Restructuring for us stands for reallocation of any resources to their best productive use. This includes, but is not limited to, investment in physical capital,

hiring labor force with proper skill mix, employing high-powered incentive contracts to reduce moral hazard in teams, acquiring “information” capital, funding research and development, doing marketing studies, and so on.

The more complex the project, the more “specialized” the contract is. More specialized project requires larger amounts of specific investment for completion and hence involves more hold-up hazard. In models of Sections 3 and 4 we consider dynamic settings, in which the story of this Section unfolds within a single moment.

### 3 Endogenous coalition-building and the evolution of collective punishment strategies

#### 3.1 Assumptions and notation

We begin by introducing assumptions and notation of the model. Consider a continuum of firms. Let  $a(t) \in [0, 1]$  be the degree of restructuring for an individual firm. At any moment firms produce in randomly matched pairs. They do not observe the type (degree of restructuring) of their partners. They agree on a contract characterized by specialization  $s \in [0, +\infty)$ . The value of the joint product (net of variable costs of production *and* specific investment made) is  $F(a_1, a_2, s)$ , where  $F$  is a monotone symmetric function, exhibiting complementarities between all arguments:  $\frac{\partial^2 F}{\partial a_i \partial s} > 0$ ,  $\frac{\partial^2 F}{\partial a_1 \partial a_2} > 0$  (consistent with the story in Section 2). This value is produced if both firms honor the contract. If a firm  $a_2$  decides to renege, it obtains defection value  $d(a_1, s)$  (if matched with a firm restructured by  $a_1$  and the contract specifies complexity  $s$ ). This value is independent of the defecting firm’s characteristics and represents pure loss for the cheated firm. If both

firms in a pair try to cheat on each other simultaneously, they both obtain zero.

Notice how the above assumptions constitute a reduced form of the game outlined in Section 2. If both firms decide to renege and not make any specific investments, they produce zero value (equivalent to just covering the costs of production in terms of that example).

Whenever two firms with identical  $a$ 's enter into a contract, they split the surplus evenly, each getting  $\frac{F(a,a,s)}{2}$ .

Time is discrete in our model. Firms may restructure incrementally at the beginning of any period subject to a convex cost  $c(t+1) = C(a(t+1) - a(t))$ .

A network, or “coalition” of firms is assumed to exist at all times, which transmits perfectly information about instances of breach of contract. The only sanction available to the coalition is the isolation of the deviating firm. Upon expulsion from the coalition, such a firm finds itself producing an autarchy output  $y_0$ . Given the discount rate  $r$ , the perpetuity on autarchy output  $y_0$  is given by  $V_0 \doteq \sum_{t=0}^{+\infty} \left(\frac{1}{1+r}\right)^t y_0$ .

For any level of restructuring  $a \in [0, 1]$  there exists  $s \in [0, 1]$ , such that  $(a, s)$  is a steady state equilibrium with multilateral punishment,

$$\sum_{t=0}^{+\infty} \frac{F(a, a, s)}{2(1+r)^t} = \frac{F(a, a, s)(1+r)}{2r} \geq d(a, s) + V_0.$$

This is guaranteed if

$$\frac{F(a, a, 0)(1+r)}{2r} - d(a, 0) > V_0 \quad \forall a.$$

Finally, we assume that for a population of fully restructured firms, the unit special-

ization of contracts  $s = 1$  is the highest specialization consistent with cooperative steady state with sanctions. This means that if all firms have  $a = 1$ , and the coalition sanctions cheaters with expulsion, honoring contracts with specialization  $s = 1$  yields the same value as cheating:

$$\sum_{t=0}^{+\infty} \left( \frac{1}{1+r} \right)^t \frac{F(1, 1, 1)}{2} = \frac{(1+r) F(1, 1, 1)}{2r} = d(1, 1) + V_0.$$

The last assumption stipulates that 1 is the maximum contract specialization sustainable by the threat of expulsion from the coalition when all firms are fully restructured.

### 3.2 Common knowledge as a pre-requisite for a cooperative “norm”

Consider the long run steady state where all firms have  $a = 1$ . If  $\frac{F(1,1,1)(1+r)}{2r} = d(1, 1) + V_0$ , fully specialized contract is the equilibrium but for all types of firms  $a < 1$  it would be optimal to deviate and hold up the partner. The equilibrium strategy of honoring the contract is weakly dominated by reneging if partner’s type is uncertain and unobservable. Thus, the assumption implicit in the definition of equilibrium is that players’ types are common knowledge. This has been lucidly explained by Rubinstein [1989]. Specifically, *it should be common knowledge that all firms have  $a = 1$* . If it were not, and firm A did not observe its partner’s type, the firm might be afraid to be held up and so cheat preemptively. Or suppose that a firm A would know that the partner firm B is fully restructured, but would not know *whether firm B knows* that firm A is fully restructured. Since the incentive constraint is binding for  $a = 1$ , any firm with  $a < 1$  would defect, so

the firm B may be afraid and strike preemptively, and so there is little reason for firm A to try to cooperate. This reasoning may be infinitely repeated.

Often overlooked, common knowledge is therefore a fundamental pre-requisite for multilateral enforcement. We argue that common knowledge that all members of the coalition have fully restructured is the elusive “social norm” of the evolutionary games literature [Bicchieri, Jeffrey and Skyrms, 1997]. We now proceed with a stylized picture of adjustment.

Consider the initial population of unstructured ( $a = 0$ ) firms. There is a potential long-run steady state in which all firms will have  $a = 1$ , this fact being common knowledge. In order to get to that steady state firms must invest resources in restructuring. However, if restructuring is unobservable, where does common knowledge come from? The conundrum of transition is precisely how to make firms restructure, if the degree of restructuring is unobservable. We propose a very simple answer to this question.

Restructured firms are assumed to be more productive and at the same time more vulnerable to hold-up. They may deal in either more primitive or more specialized contracts. Primitive contracts involve less hold-up hazard than specialized contracts, but the latter are more productive. Restructuring alters the incentives to engage in hold-up because restructuring and contract specialization are complementary. The more a firm restructures, the more value it places on ambitious highly specialized contracts, the higher its opportunity cost of deviating.

Therefore, for a static coalition using a multilateral punishment strategy (MPS) to be effective in preventing deviations, MPS must be made conditional on the *lowest* potential type of enterprises that may be present in the coalition. If the incentive compatibility

constraint binds for this lowest type, it will be a fortiori satisfied for all higher types.

The coalition will benefit from the uniform full restructuring of all firms since that maximizes their productivity. In order to get there, all potential deviators should be weeded along the path, so that in the steady state the universally full restructuring is common knowledge. This requires a dynamic path on which the incentives of the firms are carefully aligned (firms find it optimal to restructure at the same pace as others). This path actually exists if the firms are ex ante identical. From the start, the coalition embraces all firms. At any period firms allocate their output between dividends and restructuring. The increase in the latter is such that a firm that invests less will find it optimal to renege on its contract immediately and will be expelled from the coalition. The dynamic trade-off is between a) not investing anything, expropriating a partner once, and being expelled from the coalition, and b) restructuring at the equilibrium pace and enjoying rewards from staying in the coalition forever. These two alternatives should be at least equally attractive for the firms to keep restructuring. This is achieved by the other variable parameter, the specialization of contracts (positively related to exposure) in each period. It must not be too high to cause an immediate widespread defection.

At any point on the equilibrium path firms reveal themselves to keep restructuring at the equilibrium rate by not reneging, and simultaneously, incentives are provided to induce firms to do this. At the end the very fact that each firm stayed in the coalition signals full restructuring. At that time the coalition can resort to the most productive contracts available without the risk that an alien type prone to breach of contract lurks among the members.

### 3.3 Symmetric equilibria

#### 3.3.1 Dynamic problem of a representative firm

The clock starts at  $t = 0$ . Since in a symmetric equilibrium firms are identical at all times, they split the output they produce evenly, obtaining  $\frac{1}{2}F(a^*(t), a^*(t), s(t))$ . In any moment  $t > 0$  each firm takes the trajectories of specialization  $s(t)$  and representative restructuring  $a^*(t)$  as given, but may decide to deviate. The general deviation scenario is as follows: the firm may continue restructuring for some time at some pace  $a(t) \neq a^*(t)$  for  $t \leq T$ . At time  $T$  the firm reneges on the contemporaneous contract collecting the defection value  $d(a^*(T), s(T))$ . Upon this, it is expelled from the coalition and produces the autarchy output in perpetuity,  $V_0 = \sum_{t=T}^{+\infty} \left(\frac{1}{1+r}\right)^{t-T} y_0$ . While on the deviation trajectory, the firm needs to camouflage itself, thereby letting the other firms get the value they would obtain in a match with a normal firm. Hence, it gets the balance  $F(a^*(t), a(t), s(t)) - \frac{1}{2}F(a^*(t), a^*(t), s(t))$ . Summarizing,

$$\begin{aligned} \max_{a(t), T} & \sum_{\tau=t}^{T-1} \left(\frac{1}{1+r}\right)^{\tau-t} \left[ F(a^*(\tau), a(\tau), s(\tau)) - \frac{1}{2}F(a^*(\tau), a^*(\tau), s(\tau)) - c(\tau) \right] \\ & + \left(\frac{1}{1+r}\right)^{T-t} [d(a^*(T), s(T)) + V_0] \end{aligned} \quad (1)$$

$$\text{s.t. } c(t+1) = C(a(t+1) - a(t))$$

Suppose,  $C(a(t+1) - a(t)) = (a(t+1) - a(t))^2$ . Then,  $a(t+1) = a(t) + \sqrt{c(t+1)}$ .

The terminal conditions are  $a(0) = 0$ ,  $a(T) \leq 1$ .

The Euler equation for this maximization problem is

$$2(1+r)\sqrt{c(t+1)} = \frac{\partial F(a_t^*, a_t, s_t)}{\partial a_t} + 2\sqrt{c(t)}. \quad (2)$$

Optimal  $T^*$  is the earliest  $T$  such that

$$\begin{aligned} & F(a^*(T), a(T), s(T)) - \frac{1}{2}F(a^*(T), a^*(T), s(T)) - c(T) \\ \leq & d(a^*(T), s(T)) - \frac{1}{1+r}d(a^*(T+1), s(T+1)) + \frac{r}{1+r}V_0. \end{aligned}$$

or infinity if no such  $T$  exists. Transversality implies  $c(T^*) = 0$  (or  $\lim_{t \rightarrow +\infty} c(t) = 0$  if  $T^* = +\infty$ ).

In equilibrium, condition (2) must be satisfied with  $a(t) \equiv a^*(t)$ .

**Proposition 1** *In any symmetric deterministic equilibrium,  $T \in \{0, +\infty\}$ .*

**Proof.** *Consider a symmetric equilibrium in which finite  $T > 0$ . Then it is better for a firm to cheat at time  $T - 1$  gaining value*

$$d(a^*(T-1), s(T-1)) + V_0$$

*instead of*

$$\frac{1}{2}F(a^*(T-1), a^*(T-1), s(T-1)) - c(T-1) + \frac{1}{1+r}V_0$$

*(by model assumptions,  $\frac{1}{2}F(a^*, a^*, s) \leq \frac{r}{1+r}d(a^*, s) + \frac{r}{1+r}V_0$ ).*

*Intuitively, if firms wait till  $T$ , they get zero defection value with probability 1. By out-*



stripping their partner by one period, they obtain a positive defection value. Consequently, no finite positive  $T$  can be an equilibrium. ■

### 3.3.2 Multiple equilibria and existence

For a given path of  $s(t)$ , there *may* be multiple equilibria. Suppose, a non-degenerate equilibrium exists (the one where  $T = +\infty$ ). The one with  $T = 0$  will also be an equilibrium simply due to self-fulfilling prophecies (if everyone expects anyone else to defect at date 0, the privately optimal strategy is to do the same). To resolve questions of equilibrium existence, we may consider a quasi-equilibrium. This is a configuration that would be an equilibrium in an economy with perfect contract enforcement (no defection option).

**Notation 1** *The value function (conditional on the paths of  $a(\cdot)$ ,  $a^*(\cdot)$ , and  $s(\cdot)$ )  $V(t)$  is*

$$\begin{aligned} V(t | \{a^*(\cdot), a(\cdot), s(\cdot)\}) &= \sum_{\tau=t}^{+\infty} \frac{F(a^*(\tau), a(\tau), s(\tau)) - \frac{1}{2}F(a^*(\tau), a^*(\tau), s(\tau)) - c(\tau)}{(1+r)^{\tau-t}} \\ &= \sum_{\tau=t}^{+\infty} \frac{F(a^*, a, s) - \frac{1}{2}F(a^*, a^*, s) - C(a(\tau) - a(\tau-1))}{(1+r)^{\tau-t}} \end{aligned} \quad (3)$$

**Definition 1** *A symmetric quasi-equilibrium is a trajectory  $a^*(t)$  such that all firms find it optimal to restructure at the common pace, if not given the option of defecting. Formally,  $a^*(t)$  should be a fixed point of the correspondence*

$$\max_{a(t)} V(0) \quad (4)$$

**Definition 2** *A quasi-equilibrium is called viable if it is also a Nash equilibrium when defection is allowed.*

**Proposition 2** *A quasi-equilibrium exists for any  $s(t)$ .*

**Proof.** *In the appendix. ■*

The equilibrium restructuring trajectory  $a^*(t)$  positively depends on the path of  $s(t)$ .

Formally:

**Proposition 3** *Consider  $s(t)$  and  $\tilde{s}(t)$ , such that  $\tilde{s}(t) \geq s(t)$  for all  $t$  and. The quasi-equilibrium paths  $a^*(t)$ ,  $\tilde{a}^*(t)$  are such that  $\tilde{a}^*(t) \geq a^*(t)$ .*

**Proof.** *In the appendix. ■*

### 3.3.3 Pareto-ranked equilibria and the choice of $s(t)$

How is  $s(t)$  determined? Given that for any  $s(t)$  there exists an equilibrium, this is a classical coordination problem. Some paths of  $s(t)$  may be better than others if they yield higher intertemporal payoffs to representative firms.

In equilibrium,  $T \in \{0, +\infty\}$ . Hence, the problem of finding best  $s(t)$  falls into two: finding  $s(t)$  that maximizes  $V(0)$  if there are no enforcement problems; and checking that the obtained quasi-equilibrium is viable as a Nash equilibrium once defection is allowed.

We argue that these two problems can be dealt with simultaneously.

Paths of  $s(t)$  resulting in non-viable quasi-equilibria can be disposed of immediately, since in actual equilibria defection is instantaneous, and no restructuring ever takes place. The social welfare is the lowest since the economy failed to take advantage of restructuring. So we need only concentrate on  $s(t)$  that result in viable quasi-equilibria. Viability implies

that in quasi-equilibrium,

$$V(t) = \sum_{\tau=t}^{+\infty} \left( \frac{1}{1+r} \right)^{\tau-t} \left[ \frac{1}{2} F(a^*(\tau), a^*(\tau), s(\tau)) - c(\tau) \right] \geq d(a^*(t), s(t)) + V_0 \quad (5)$$

at all  $t$ . Here  $a^*(t)$  are the fixed points of the maximum correspondence (4).

**Proposition 4** *The socially optimal  $s(t)$  must satisfy (5) as an equality for all  $t \geq 0$  such that  $s(t) < 1$  with a possible exception of a zero-measure set.*

**Proof.** *In the appendix.* ■

**Notation 2** *We denote the socially optimal path of contract specialization by  $s^*(t)$ .*

**Proposition 5** *The socially optimal  $s^*(t)$  and induced symmetric profiles  $a^*(t)$  constitute a unique coalition-proof equilibrium.*

**Proof.** *In the appendix.* ■

### 3.4 Properties of equilibrium adjustment paths

The preceding section has characterized coalition proof equilibrium paths. Proposition 4 reduced the problem of finding this equilibrium to solving

$$V(t) = d(a^*(t), s(t)) + V_0$$

in conjunction with the Euler equations (2) and symmetric equilibrium condition  $a(t) \equiv a^*(t)$ . We supplement these with the recursive formula for the value function and the

incentive compatibility constraint to obtain a system

$$\begin{aligned}
c_{t-1} &= \frac{1}{4(1+r)^2} \left[ \frac{\partial F(a_t^*, a_t, s_t)}{\partial a_t} + 2\sqrt{c_t} \right]^2 \\
a_{t-1} &= a_t - \sqrt{c_t} \\
a_t^* &\equiv a_t \\
V_{t-1} &= \frac{1}{2} F(a_{t-1}^*, a_{t-1}^*, s_{t-1}) - c_{t-1} + \frac{1}{1+r} V_t \\
V_{t-1} &= d(a_{t-1}, s_{t-1}) + V_0
\end{aligned}$$

As this problem is unsolvable in closed form, we simulate the model numerically. The system can be solved backwards starting from the terminal conditions  $a(T) = 1$ ,  $s(T) = 1$ ,  $c(T) = 0$ ,  $V(T) = d(1, 1) + V_0$ .

Figure 1 depicts a sample equilibrium path. Adjustment begins rather cautiously as firms set rather unambitious contractual goals. They do that out of fear of the breach of contract, knowing that opportunity costs are relatively low. At the same time firms do not defect not because their current surplus is large, but because staying in the coalition gives them an option value of profitable business opportunities in the future. Notice that because this option value is positive, the specialization levels observed along the adjustment path are not consistent with *stationary* equilibria. It is the expectation of future increase in productivity that keeps businesses on the bandwagon. In finite time, the entire economy has completed restructuring, entering the long run steady state.

### 3.4.1 Adjustment with and without outside contract enforcement

To highlight the implications of the need to align incentives in the coalition we compare this path to an equilibrium adjustment path in the same economy, but with no defection option. One immediately realizes that specialization in this economy is kept at the feasible maximum:  $s \equiv 1$ . This maximizes contract surplus for any values of  $a$ , and is feasible because the firms cannot cheat anyway. Consequently, output is higher along the entire path, which allows for faster restructuring (see Figure 2). The comparison between an economy with and without perfect outside enforcement reveals the contribution of the need to align incentives to the speed of adjustment. Another instructive comparison is between spending on restructuring on both paths (see Figure 3). The economy without outside contract enforcement is held back in the initial stages of adjustment when the need to prevent deviations is the greatest.

### 3.4.2 Monotonicity of specialization path

It may seem that  $s(t)$  must be increasing along the adjustment path. This is not true for all functional forms of  $d(\cdot)$  and  $F(\cdot)$ . An example is provided in Figure 4, where function  $d(\cdot)$  was made very insensitive to  $s$  in the lower ranges of  $a$ , and very sensitive to  $s$  at high  $a$ . When firms are unstructured, the defection value is small. Consequently, they may take advantage of specialized contracts for a while. However, soon the incentive constraint bites, and the coalition is forced to cut back specialization. It then follows an upward path, culminating in full specialization only when the universal restructuring is complete.

This is more than a mere theoretical possibility. An extremely outdated economy

with a legacy of a highly complex production structure may not even present enough opportunities for hold-up. Say, instead of producing radios with the transistors that a supplier sent, the radio firm sells these for cash in a flea market. If value of the products that unstructured firms can produce has fallen dramatically, the gain from holding up a partner is also small. However, as soon as new activity sprouts, the defection will look more and more attractive. This could generate a U-shaped pattern of specialization. Instead, an agricultural economy would never go through this phase because it never produced specialized goods before. This might distinguish Russia and China, for example.

### 3.5 Importance of implicit signalling

The previous section painted a picture of restructuring as a gradual process. It may be argued that this is an artifact of the convex restructuring costs assumption<sup>3</sup> and the need to generate funds internally to finance the adjustment. This section argues that restructuring is gradual because of the need to establish common knowledge of the process.

Consider what happens along the adjustment path outlined in Section 3.3. All firms restructure at the common pace  $a^*(t)$ . Consider a firm that for some reason finds itself behind:  $a(t) < a^*(t)$ . Because it starts with smaller value of the state variable, its intertemporal payoff is lower than that of a compliant firm:

$$\tilde{V}(t) < V(t)$$

---

<sup>3</sup>Notice that with linear felicity function, no firm in our model can be liquidity-constrained.

But in the coalition-proof equilibrium,

$$V(t) = d(a^*(t), s(t)) + V_0$$

Consequently,

$$\tilde{V}(t) < d(a^*(t), s(t)) + V_0$$

and the firm lagging behind finds it optimal to defect immediately. The fact that such defections are not observed on the equilibrium path, therefore, signals that all firms push onward together, and at the time  $T$  where  $a^*(T) = 1$ , it is common knowledge that restructuring has been universal.

It is instructive to consider a modification of the model in which firms' budget constraint is radically relaxed in the following sense. Suppose that at time  $t = 0$  firms are given a lump-sum amount  $S$  which is sufficient to propel every firm to full restructuring immediately (suppose  $S$  covers costs of importing *all* factors of production). Will the firms exercise this option? The answer is no.

Assuming that every other firm has honestly spent  $S$  on restructuring, if an individual firm also restructures, it obtains a perpetuity  $\frac{F(1,1,1)(1+r)}{2r} = d(1,1) + V_0$ . However, by defecting immediately and diverting  $S$  for dividends gives  $S + d(1,1) + V_0 > \frac{F(1,1,1)(1+r)}{2r}$ . Therefore, it is a best response to deviate. The only equilibrium path in which cooperation takes hold is the one identified in Section 3.3.

### 3.6 Constrained efficiency

This section inquires into issues of efficiency. The need to enforce contracts is a fundamental constraint on any economy. Therefore, our comparison benchmark is an economy with no outside contract enforcement, but perfect information. If restructuring were observable, would an economy be able to get to the long run steady state faster?

In this alternative setup, any path  $a(t)$  can be made an equilibrium, provided it satisfies the incentive compatibility condition (5).  $a(t)$  need not be a fixed point of the best response correspondence (4). Once the equilibrium specifies  $a(t)$ , the (observed) non-compliers are threatened by expulsion from coalition.

Note that this is also equivalent to the problem of a social planner, able to dictate the pace of restructuring to firms; it is in this sense that the equilibrium is a constrained optimum. Consider the problem of maximizing (3) having imposed  $a(t) \equiv a^*(t)$ :

$$\max V(\{a^*(\cdot), s(\cdot)\}) = \max \sum_{\tau=0}^{+\infty} \left( \frac{1}{1+r} \right)^\tau \left[ \frac{1}{2} F(a^*(\tau), a^*(\tau), s(\tau)) - c(\tau) \right]$$

It may seem, there is an externality that is internalized by the social planner. However, since  $F(a_1, a_2, s)$  is symmetric for  $a_1$  and  $a_2$ , the Euler equations turn out to be exactly the same in the social planner's problem (2) as in the decentralized equilibrium of section 3.3 (observe that  $\frac{\partial F(a^*, a, s)}{\partial a} = \frac{1}{2} \frac{\partial F(a^*, a, s)}{\partial a} + \frac{1}{2} \frac{\partial F(a^*, a, s)}{\partial a^*} = \frac{dF(a^*, a^*, s)}{da^*}$  if  $a = a^*$ ). We conclude that the decentralized equilibrium with unobservable restructuring is efficient. The reason behind this result is that each firm considers itself a residual claimant when calculating



its optimal pace of restructuring, thus internalizing the externality<sup>4</sup>.

This is a remarkable result. It says that the dynamic coalition is construed in a way that reveals information at no cost to the economy (in terms of missed business opportunities). Thus, the coalition is able to overcome the information problems perfectly.

## 4 Limitations of liability and coalition constituency

This section presents our second model, formally detached from the first, which focuses on implications of fundamental, non-legal liability limitations for evolution of enforcement institutions. The limitation is that if a firm disintegrates and its assets and factors of production are recycled in the economy, the new firm that happens to employ these factors, or acquire the assets, may not bear responsibility for the actions of the predecessor. Despite all legacies of the past embodied in the stocks of human, physical, and infrastructure capital, in that sense only restructuring is indeed starting from a blank page.

### 4.1 Assumptions of the model

#### 4.1.1 Production and defection

This model shares many assumptions with the one presented in the previous section. A major simplification is that both restructuring and contract specialization are binary variables. There is a continuum of firms which can potentially be of two types: 1, 2. In the beginning, all firms are of type 1 (unrestructured). Type 2 firms are restructured firms. As any firm is but a mix of factors of production, it is useful to think about restructuring

---

<sup>4</sup>This would not hold if the production function were asymmetric, and the population of firms were divided into two classes, say, upstream and downstream, and they would enter the function differently. However, as long as each firm on average plays both roles, the efficiency result will hold nevertheless.

in this context as a death of an old firm and birth of a new one, whose factor mix has a substantial overlap with that of the old one.

Production in this economy is also carried out by pairs of firms. Firms of types  $i$  and  $j$  may enter into two types of contractual agreements: a primitive or a specialized one. Contracts last for one period and are characterized by the net surpluses accruing to both parties: firms of type  $i$  and  $j$  get respectively  $Y_{ij}$  and  $Y_{ji}$ . For simplicity, we make the indivisibility assumption: the two firms are not allowed to divide the total surplus in any other way. Either firm may cheat on the other. This way firms obtain the defection value  $D$ . If the firm of type  $j$  reneges on the agreement, it gets a surplus of  $D_{ji}$ , while the firm of type  $i$  gets  $(-D_{ji})$  (this being a zero-sum game) and vice versa if it is type  $i$  firm that defects.

A *primitive* contract is similar to the specialized one but the surpluses created are  $y_{ij}$  and  $y_{ji}$ , where  $y_{ij} < Y_{ij} \forall i, j$ . The defection values are zero:  $d_{ij} = 0 \forall i, j$ .

Adopting the assumptions of Section 3 in the binary case, we make the following assumptions about relative productivities of various matches:

$$Y_{11} < Y_{12} \leq Y_{21} < Y_{22},$$

$$y_{11} < y_{12} \leq y_{21} < y_{22} < Y_{11}$$

Each period, unstructured firms get an opportunity to restructure with probability  $\rho < 1$ . Restructuring is costless. Firms may or may not take advantage of this opportunity (restructuring is a decision variable).  $p_1(t)$  and  $p_2(t)$  denote proportions of firms of each type at time  $t$ ,  $p_1(t) + p_2(t) \equiv 1$ .

If at any time firms of both types coexist in the economy, the distribution of the

types of *matches* created is determined solely by population proportions. Literally, the proportion of  $(1, 1)$  matches is  $p_1^2$ , that of  $(2, 2)$  matches is  $p_2^2$ , and there are  $2p_1p_2$  mixed  $(1, 2)$  matches. This assumption implies that restructured businesses cannot segregate themselves from the rest of the economy.

The assumptions on the defection values will be presented below. We again assume that firms maximize their intertemporal surplus (inclusive of defection gains/losses), discounted at rate  $r$ . As a shortcut, we sometimes use  $\delta = \frac{1}{1+r}$  (the discount factor).

#### 4.1.2 Information

In contrast to Section 3, the information on which firms can condition their choices, is the type of the firm  $\{1, 2\}$ , and, if they belong to a coalition, whether or not the other party has ever cheated on the contracts enforced by that coalition. However, if an unrestructured firm has cheated and later became type 2, no memory of the *original* defection remains. This captures the central assumption of liability limitations. A restructured firm is a new mix of factors of production which has a substantial overlap with the mix in the unrestructured firm. We assume it is impossible to discriminate on the basis of such things as, for example, the fact that 75% of employees of a restructured firm were previously on the roll of an unrestructured firm that had cheated, or the firm is housed in the same building, and so forth.

#### 4.1.3 Coalitions and contracting

Firms may organize into networks providing for collective sanctions for breach of contract. We call such networks coalitions. Individual firms may join if the value of staying in the coalition exceeds that of opting out. Coalitions transmit perfectly information about

instances of breach of contract.

Every period, having observed the type of their match, firms decide whether to sign a contract, and what type of contract, primitive or specialized. Hence, the additional choice variables of the firms of type  $i$  are:

1. Type of the contract, when matched with a firm of type  $j$  that has never reneged on contracts,  $C_{ij}^H(t) \in \{S, P, N\}$  (specialized, primitive, or no contract).
2. Type of the contract, when matched with a firm of type  $j$  that has previously cheated on a partner,  $C_{ij}^C(t) \in \{S, P, N\}$ .
3. Whether to renege on a contract.

## 4.2 Static coalitions

Before endeavouring to describe transition dynamics it may be useful to describe two steady states: the one that prevails before the restructuring, and the one that will eventually be reached.

Since primitive contracts are trivially enforceable ( $d_{ij} = 0 < y_{ij}$ ), here we discuss conditions for enforcement of specialized contracts in stationary equilibria (when all enterprises remain forever of the same type, say, 1). In absence of collective sanctions, firms have incentives to renege on specialized contracts if  $Y_{11} < D_{11}$  (since there is a continuum of firms, the threat of unilateral sanctions can be ignored).

If the coalition of all the firms sanctions breach with exclusion, there is a trade-off between

- being honest and staying in the coalition, expecting to get  $\sum_{t=0}^{+\infty} Y_{11} \delta^t = \frac{1+r}{r} Y_{11}$

- defecting and getting  $D_{11}$ .

The threat of exclusion is viable if

$$\frac{1+r}{r}Y_{11} > D_{11}. \quad (6)$$

Notice that exclusion (which dictates that coalition members not enter into *any* contracts with cheaters) is the strongest form of punishment available. To ensure that coalition members do this instead of signing primitive contracts, we assume that a firm is punished for having any business with cheaters. This ensures that no firm ever has an incentive to deviate.

Similarly, we assume that specialized contracts are sustainable in a stationary equilibrium in which all firms are restructured:

$$\frac{1+r}{r}Y_{22} > D_{22}. \quad (7)$$

### 4.3 An equilibrium adjustment path

#### 4.3.1 Conditions for existence of a joint coalition

We start our equilibrium analysis at time 0. Before  $t = 0$ , firms were organized into a coalition enforcing specialized  $(1, 1)$  contracts, thus each firm have been getting surplus  $Y_{11}$  for  $t < 0$ . At time 0 the economy learns about the restructuring option (firms begin getting the random restructuring opportunity for  $t \geq 1$ ). We will assume that on the adjustment path all firms restructure when given the opportunity to do, and later show that this in fact constitutes an equilibrium.

If this is so, the relative proportions of types are

$$\begin{aligned} p_1(t) &= (1 - \rho)^t \\ p_2(t) &= 1 - (1 - \rho)^t \end{aligned} \tag{8}$$

For all  $t > 0$ , restructured and unrestructured firms will coexist. We first study when a joint coalition of firms of both types is viable. It may seem that in light of conditions (6), (7) it is enough to have

$$\frac{1+r}{r} Y_{12} > D_{12} \tag{9}$$

$$\frac{1+r}{r} Y_{21} > D_{21} \tag{10}$$

However, the situation is more complicated as unrestructured firms expect to get punishment only until they restructure. This magnifies the effective discount rate.

Consider the trade-off of an unrestructured firm whether to cheat or not at time  $T$  on a contract  $(1, j)$ ,  $j = 1, 2$ . Conditional on still being unrestructured at  $T$ , the probability of restructuring at time  $t > T$  is  $\frac{p_1(t)}{p_1(T)}$  (since the aggregate proportions are also the individual probabilities). Under the expectation that the coalition will prevail indefinitely into the future, the firm expects to get

$$D_{1j} + \sum_{t=T+1}^{+\infty} \left( 1 - \frac{p_1(t)}{p_1(T)} \right) (p_1(t) Y_{21} + p_2(t) Y_{22}) \delta^{t-T},$$

if it cheats, and

$$Y_{1j} + \sum_{t=T+1}^{+\infty} \frac{p_1(t)}{p_1(T)} (p_1(t) Y_{11} + p_2(t) Y_{12}) \delta^{t-T} + \sum_{t=T+1}^{+\infty} \left(1 - \frac{p_1(t)}{p_1(T)}\right) (p_1(t) Y_{21} + p_2(t) Y_{22}) \delta^{t-T}$$

otherwise.

$$\begin{aligned} D_{1j} &> Y_{1j} + \sum_{t=T+1}^{+\infty} \frac{p_1(t)}{p_1(T)} (p_1(t) Y_{11} + p_2(t) Y_{12}) \delta^{t-T} \\ &= Y_{1j} + \sum \frac{(1-\rho)^t}{(1-\rho)^T} [(1-\rho)^t Y_{11} + (1 - (1-\rho)^t) Y_{12}] \delta^{t-T} \\ &= \begin{cases} Y_{12} \frac{1+r}{\rho+r} + \frac{(1-\rho)^{T+2}}{2\rho-\rho^2+r} (Y_{11} - Y_{12}), j = 2 \\ Y_{11} + (1-\rho) \frac{Y_{12}}{\rho+r} + \frac{(1-\rho)^{T+2}}{2\rho-\rho^2+r} (Y_{11} - Y_{12}), j = 1 \end{cases} \end{aligned}$$

The term  $\frac{(1-\rho)^{T+2}}{2\rho-\rho^2+r} (Y_{11} - Y_{12})$  is negative, and converges to zero as  $T$  becomes large.

The necessary conditions for the coalition to be viable at least for some  $T$  are

$$\begin{cases} D_{12} \leq Y_{12} \frac{1+r}{\rho+r} \\ D_{11} \leq Y_{11} + (1-\rho) \frac{Y_{12}}{\rho+r} \end{cases} \quad (11)$$

which are stronger than either (9) or (6). It is in this sense that the dynamic nature of transition presents challenges to contract enforcement. While specialized contracts only require (6), (7), (9), and (10) to be enforceable in a stationary equilibrium, stronger conditions (11) are necessary (not even sufficient) on a dynamic adjustment path. Whether or not (11) hold, depends to a large extent on the relative magnitudes of the discount rate  $r$  and restructuring rate  $\rho$ . For  $r = \rho = 0.05$ , (11) imply  $D_{12} \leq 10.5Y_{12}$ , while the

stationary assumption (9) only requires  $D_{12} \leq 21Y_{12}$ , the two-fold difference!

Enforceability conditions are slightly stretched for type 2 firms as well, they require

$$D_{22} \leq \frac{1+r}{r}Y_{22} + (1-\rho)^T \frac{1+r}{\rho+r}(Y_{21} - Y_{22}),$$

which for large enough  $T$ , though, coincides with (10). There is also a possibility that even if incentive compatibility for individual firms is assured, such an equilibrium path is not coalition-proof. Intuitively, the group of all restructured firms may decide to collectively desert the joint coalition when the number of type 1 businesses becomes small. Why should the group of restructured firms bear the cost of enforcing mixed contracts (by excluding type 2 firms that cheated on type 1s) if such contracts increasingly become a rarity? A representative type 2 firm in the sub-coalition has an expected value<sup>5</sup> of

$$p_1(T) D_{21} + p_2(T) Y_{22} + \sum_{t=T+1}^{+\infty} p_2(t) Y_{22} \delta^{t-T},$$

if the sub-coalition decides to quit at time  $T$ . If the desertion never happens, representative firm gets

$$\sum_{t=T}^{+\infty} (p_1(t) Y_{21} + p_2(t) Y_{22}) \delta^{t-T}$$

Using (8) to substitute for  $p_{it}$ , the former expression is smaller than or equal to the latter

---

<sup>5</sup>Computed under the pessimistic scenario that unrestructured firms will stick to the strategy of punishing all type 2 firms.



if

$$\begin{aligned}
p_1(T) D_{21} &\leq \sum_{t=T}^{+\infty} p_1(t) Y_{21} \delta^{t-T} \Leftrightarrow \\
D_{21} &\leq \sum_{t=T}^{+\infty} [(1-\rho)\delta]^{t-T} Y_{21} \Leftrightarrow \\
D_{21} &\leq \frac{Y_{21}}{1-\delta(1-\rho)} = \frac{1+r}{\rho+r} Y_{21}
\end{aligned} \tag{12}$$

This condition turned out to be independent of  $T$ . Even if (10) holds, it may still be the case that

$$\frac{1+r}{\rho+r} Y_{21} < D_{21} \leq \frac{1+r}{r} Y_{21}.$$

This says that even if a joint coalition was viable in a stationary state (where proportions are constant), it may not be on a non-stationary adjustment path.

What happens when any of the conditions (11) or (12) are not satisfied (assumption *NJC*, for “No Joint Coalition”)? The joint coalition never takes hold. We summarize this in

**Proposition 6** *The joint coalition of firms of both types is non-viable under any of the following conditions:*

$$\begin{aligned}
D_{21} &> \frac{1+r}{\rho+r} Y_{21} \\
D_{12} &> \frac{1+r}{\rho+r} Y_{12} \\
D_{11} &> Y_{11} + (1-\rho) \frac{Y_{12}}{\rho+r}
\end{aligned}$$

*Firms therefore obtain surpluses  $y_{12}$  and  $y_{21}$  in mixed matches. We refer*

The rest of our analysis assumes that one of the conditions in proposition 6 indeed destroys the potential joint coalition.

#### 4.3.2 Coalition jump-starting, coalition unraveling

If the joint coalition is non-viable, perhaps, the two homogeneous coalitions may be able to solve enforcement problems for same-type matches.

**Restructured firms** We consider first a potential coalition of restructured firms by verifying whether it is able to deter breach of  $(2, 2)$  contracts by the harshest possible punishment, starting at a moment  $T$ . Expected intertemporal payoff to a firm that honors the contract is

$$Y_{22} + \sum_{t=T+1} (p_1(t) y_{21} + p_2(t) Y_{22}) \delta^{t-T},$$

compared to a cheater's payoff

$$D_{22} + \sum_{t=T+1} p_1(t) y_{21} \delta^{t-T}.$$

The former is greater or equal to the latter if

$$\begin{aligned} Y_{22} + \sum_{t=T+1}^{+\infty} p_2(t) Y_{22} \delta^{t-T} &\geq D_{22} \Leftrightarrow \\ Y_{22} \left( 1 + \sum_{t=T+1}^{+\infty} (1 - (1 - \rho)^t) \delta^{t-T} \right) &\geq D_{22} \Leftrightarrow \\ \frac{2r + 1}{r} - \frac{D_{22}}{Y_{22}} &\geq \frac{(1 - \rho)^{T+1}}{r + \rho} \end{aligned} \tag{13}$$

The RHS of the last condition is decreasing in  $T$  since  $\rho \in (0, 1)$ . Consequently, this condition will hold for any parameter values for large enough  $T$ .

**Notation 3** *Suppose  $s$  solves (13) as an equality:*

$$\frac{(1 - \rho)^{s+1}}{r + \rho} = \frac{2r + 1}{r} - \frac{D_{22}}{Y_{22}}$$

$$s = -1 + \ln \left( (r + \rho) \left[ \frac{2r + 1}{r} - \frac{D_{22}}{Y_{22}} \right] \right) / \ln(1 - \rho) \quad (14)$$

Time  $[s] + 1$  is the earliest period when the coalition of type 2 firms is viable. This is an important milestone on the adjustment path. Prior to  $[s] + 1$ , restructured firms must resort to primitive contracts in all their dealing. Thereafter they become collectively able to enforce specialized contracts among restructured firms, enjoying higher surpluses. The economy as a whole, with the proportion of such firms converging to unity, is finally on the last lap to the long-run steady state.

A few simple comparisons follow straightforwardly from (14): reorganization occurs later ( $s$  is greater) when either

- immediate rewards from defection are greater ( $D_{22}$  is larger),
- surplus of specialized contracts is lower ( $Y_{22}$  is smaller),
- restructuring proceeds at a faster rate ( $\rho$  is greater),
- or discount rate  $r$  is larger (under an additional assumption  $\rho > 2r^2$ ).

**Unrestructured firms** Consider now the trade-off of an unrestructured firm whether to cheat or not at time  $T > [s]$ . Conditional on still being unrestructured at  $T$ , the

probability of restructuring at time  $t > T$  is  $\frac{p_1(t)}{p_1(T)}$ . Under the expectation that the coalition of type 1 will prevail indefinitely into the future, a firm expects to get

$$D_{11} + \sum_{t=T+1}^{+\infty} \frac{p_1(t)}{p_1(T)} p_2(t) y_{12} \delta^{t-T} + \sum_{t=T+1}^{+\infty} \left(1 - \frac{p_1(t)}{p_1(T)}\right) (p_1(t) y_{21} + p_2(t) Y_{22}) \delta^{t-T},$$

if it cheats, and

$$Y_{11} + \sum_{t=T+1}^{+\infty} \frac{p_1(t)}{p_1(T)} (p_1(t) Y_{11} + p_2(t) y_{12}) \delta^{t-T} + \sum_{t=T+1}^{+\infty} \left(1 - \frac{p_1(t)}{p_1(T)}\right) (p_1(t) y_{21} + p_2(t) Y_{22}) \delta^{t-T}$$

if it does not, the latter terms of both expressions being the same due to the liability limitation assumption. It is preferable to cheat whenever

$$\begin{aligned} D_{11} &> Y_{11} \left(1 + \sum_{t=T+1}^{+\infty} \frac{p_1^2(t)}{p_1(T)} \delta^{t-T}\right) \\ &= Y_{11} \left(1 + \sum_{t=T+1}^{+\infty} (1-q)^{2t-T} \delta^{t-T}\right) \\ &= Y_{11} \left(1 + \frac{(1-q)^{T+2}}{r + 2\rho - \rho^2}\right) \end{aligned}$$

The limit of the last expression when  $T$  gets large is  $Y_{11}$ , and  $D_{11} > Y_{11}$ . Therefore, there exists time when the coalition will be no longer viable. However, if the MPS breaks down at time  $T$ , this alters the trade-off at time  $T - 1$ , as cheaters do not expect to get any punishment at  $t \geq T$ . Since  $D_{11} > Y_{11}$ , they would prefer to cheat, and so the MPS does not work even at  $T - 1$ . The coalition unravels as we repeat backward induction.

How robust is the conclusion that on an adjustment path, a coalition with shrinking

constituency never takes hold, even temporarily? The outcome is homomorphic to that in the famous “centipede” game [Rosenthal, 1981; Binmore, 1987]. While in the unique Sequential Nash equilibrium the game ends in the first round of play, this prediction was refuted in an experimental study by McKelvey and Palfrey [1992], who have most of the time observed long histories of actual play. A more reserved prediction in the transition context, therefore, would be that the old networks will function for a while but will eventually decline, marking switch to primitive contracts.

### 4.3.3 Individual rationality of restructuring choice

So far we have ignored the issue of the individual rationality of restructuring. Instead we have been assuming that firms take the first available opportunity to restructure. Below we verify whether this is indeed their optimal strategy.

A firm that at time  $T$  passes the opportunity to restructure (and commits never to restructure later) obtains expected discounted surplus of

$$\sum_{t=T}^{+\infty} [p_1(t) y_{11} + p_2(t) y_{12}] \delta^{t-T}$$

Otherwise it would obtain (assuming for simplicity that  $T < [s]$ )

$$\sum_{t=T}^{[s]} [p_1(t) y_{21} + p_2(t) y_{22}] \delta^{t-T} + \sum_{t=[s]+1}^{+\infty} [p_1(t) y_{21} + p_2(t) Y_{22}] \delta^{t-T}.$$

It is obvious that the latter payoff dominates the former, as  $y_{21} > y_{11}$ ,  $Y_{22} > y_{22} > y_{12}$ . (The same conclusion is obviously reached if the firm passing the opportunity does not actually commit to this strategy in the future). Therefore, it is indeed individually optimal

for firms to restructure at their first opportunity.

#### 4.3.4 Summary of properties of the adjustment path

The economy is initially in the steady state with a MPS in place enforcing specialized contracts. Surplus of a representative firm is  $Y_{11}$ . Suddenly, the environment changes, making the current organization of production suboptimal. Firms learn about the change, and start randomly getting opportunities to restructure. All of them take their first available opportunity to do so.

The existing coalition is destroyed when the news arrives, so the firms that have not yet had a chance to restructure enter only into primitive contracts with each other. Under the NJC assumption, there exists no feasible collective mechanism to enforce mixed specialized contracts, either. For all  $t \leq [s]$ , restructured firms enter only into primitive contracts with each other. The situation changes at  $t = [s] + 1$ , where the new homogeneous coalition forms, enforcing specialized  $(2, 2)$  contracts. The economy then gradually converges to the long-run steady state in which all firms are restructured.

#### 4.3.5 Transitory output decline

We show that our model exhibits transitory output decline, if we interpret aggregate surplus in our model as output net of investment and resource costs. Subject to that qualification, the surplus of an average firm starts at  $Y_{11}$  just before the onset of restructuring. It falls to  $y_{11} < Y_{11}$  at  $t = 0$ , and until time  $[s] + 1$  is given by

$$p_1^2(t) y_{11} + p_1 p_2 (y_{12} + y_{21}) + p_2^2 y_{22}$$

For parameter values such that  $[s] > 0$ , the surplus will be below  $Y_{11}$  all  $t = 0, \dots, [s]$  since  $y_{ij} < Y_{11}$ . For  $t > [s]$ , the surplus of an average firm is

$$p_1^2(t) y_{11} + p_1 p_2 (y_{12} + y_{21}) + p_2^2 Y_{22}$$

As  $t \rightarrow \infty$ ,  $p_1(t) \rightarrow 0$ , and this average surplus converges to  $Y_{22} > Y_{11}$ . Hence, the economy will eventually overshoot the initial level  $Y_{11}$ . Therefore, along the equilibrium adjustment path, aggregate surplus follows a U-shaped trajectory.

#### 4.4 Stagnation equilibrium

So far we have focused on an equilibrium in which adjustment was individually optimal for firms. This optimality was however derived under the assumption that everyone else restructures, and therefore, represents a classic coordination game. There is another, stagnant equilibrium in which no firm ever restructures.

For an individual firm that got an restructuring option, expected payoff in all following periods is  $y_{21}$  because the rest of the firms do not restructure, and because the coalition of type 1 firms is not *expected* to enforce the one mixed specialized contract<sup>6</sup>.

Which equilibrium is better? The expected intertemporal surplus of a representative firm at time 0 is

$$V(\rho) = \sum_{t=1}^{+\infty} [p_1^2(t) y_{11} + p_1 p_2 \cdot (y_{21} + y_{12})] \delta^t + \sum_{t=0}^{[s]} p_2(t) y_{22} \delta^t + \sum_{t=[s]+1}^{+\infty} p_2^2(t) Y_{22} \delta^t.$$

For  $\rho \rightarrow 1$ ,  $V(\rho) \rightarrow y_{11} + \frac{Y_{22}}{r} > Y_{11} \frac{1+r}{r}$  for small enough  $r$ . For  $\rho \rightarrow 0$ , the new coalition

---

<sup>6</sup>Note that as in all kinds of collective punishment equilibria this is purely a matter of coordination.

formation date  $s \rightarrow +\infty$  (see expression 14), and consequently,  $\lim_{\rho \rightarrow 0} V(\rho)$  is bounded from above by  $\frac{y_{22}(1+r)}{r} < \frac{Y_{11}(1+r)}{r}$ .

Therefore, there exist both ranges of parameter values where adjustment alternatively is or is not socially optimal. However, even when it is socially optimal, it involves transitory surplus decline.

## 5 Conclusion

We have studied evolution of informal contract enforcement, highlighting the role of two factors, common knowledge of the types (induced preferences) of other players, and liability limitations stemming from the transient nature of a firm. Our models yield a surprisingly rich set of predictions which we explore in the context of an economy in transition. If the economy is eventually to fully restructure and resume growth, as our first model argues, it will have to be able to take advantage of specialized techniques of production; this is only possible if trust is established among stranger firms. We have argued that this trust is not hard-wired in the evolutionary game-theoretic sense, but rather stems from the common knowledge of the preferences of other firms. If general investment (or restructuring) raises the opportunity costs of breach of contract, the economy must find a way to credibly signal that the investment has in fact occurred. On the equilibrium adjustment path this need manifests itself in the spell of relatively primitive contracts, with specialization below the long-run level. By deliberately operating at less than full throttle, the firms are signalling that they are adjusting, thus investing in trust. We have demonstrated that this feature is central to the success of transition, and is robust to relaxation of the convex adjustment costs assumption. Moreover, in an informational



sense this self-organization process is efficient, which gives credit to the invisible hand and some hope for the ultimate success of some of the most backward transition economies, despite the inertia and blunders in upgrading of the legal edifice.

Our second model made the point that certain fundamental, non-legal liability limitations, such as the impossibility to punish individual factors of production left when firms disintegrate, impose extra strain on the informal contract enforcement institutions in times of rapid change. Conditions, sufficient for their smooth operation in a stationary economy are no longer so in these times. Consequently, existing coalitions may be gone before the new have had time to develop, implying a period of turmoil and seeming regress. This turmoil is inevitable, but it will give place to newly restored order when the constituency for the new coalition reaches a critical level. The economy will be back on track, with no intervention of social planner or external assistance.

Our explicitly dynamic approach has allowed us to overcome conceptual difficulties that endanger any contribution to economics of institutions, such as the indeterminateness of the institutional content and emphasis on persistence. The fact that an economy can regain orderliness with no radical intervention, on its own, makes a case for fine-tuning and the corresponding shift of research focus away from multiple steady states alarmism.

## A Technical appendix

### A.1 Proof of proposition 2

**Proof.** The payoff functions of the firms  $V(0)$  are supermodular with respect to their own strategy variables  $\{a(t)\}_{t=0}^{+\infty}$  :

$$\begin{aligned}\frac{\partial^2 V}{\partial a(t) \partial a(t+1)} &= \left(\frac{1}{1+r}\right)^{t+1} C'''(\cdot) > 0, \\ \frac{\partial^2 V}{\partial a(t) \partial a(t+k)} &= 0, \quad k > 1\end{aligned}$$

Further, firms' payoff have decreasing differences in their strategy variables  $a$  and strategies of their opponents  $a^*$ :

$$\begin{aligned}\frac{\partial^2 V}{\partial a(t) \partial a^*(t)} &= \left(\frac{1}{1+r}\right)^t \frac{\partial^2 F(a^*(t), a(t), s(t))}{\partial a(t) \partial a^*(t)} > 0, \\ \frac{\partial^2 V}{\partial a(t) \partial a^*(t+k)} &= 0, \quad k \neq 0\end{aligned}$$

This is sufficient for equilibrium existence as demonstrated by Milgrom and Roberts [1990]. ■

## A.2 Proof of proposition 3

**Proof.** This follows because individual payoffs (3) have increasing differences in  $(a, s)$  and  $(a^*, s)$  [Milgrom and Roberts, 1990]:

$$\begin{aligned}\frac{\partial^2 V}{\partial a(t) \partial s(t)} &= \left( \frac{1}{1+r} \right)^t \frac{\partial^2 F(a^*, a, s)}{\partial a \partial s} > 0 \\ \frac{\partial^2 V}{\partial a^*(t) \partial s(t)} &= \left( \frac{1}{1+r} \right)^t \frac{\partial^2 F(a^*, a, s)}{\partial a^* \partial s} > 0 \\ \frac{\partial^2 V}{\partial a(t) \partial s(t+k)} &= \frac{\partial^2 V}{\partial a^*(t) \partial s(t+k)} = 0, \quad k \neq 0\end{aligned}$$

■

## A.3 Proof of proposition 4

**Proof.** Suppose  $V(t) > d(a^*(t), s(t)) + V_0$  for  $t \in T$ ,  $\mu(T) > 0$ . Consider  $\tilde{s}(t) > s(t)$  for  $t \in T$ ,  $\tilde{s}(t) = s(t)$ ,  $t \notin T$ , and such that  $\|\tilde{s} - s\| = \sup_t |\tilde{s}(t) - s(t)|$  is infinitesimal. Consider  $\tilde{a}^*(t)$  – the quasi-equilibrium profile of restructuring corresponding to  $\tilde{s}(t)$ . By continuity of solution to a system of differential equations, the distance  $\|\tilde{a}^* - a^*\|$  will also be infinitesimal.

1. For all  $t \in T$ ,

$$V(t, \{\tilde{a}^*(\cdot), \tilde{s}(\cdot)\}) > V(t, \{a^*(\cdot), s(\cdot)\}).$$

Moreover, by continuity of the difference  $V(t) - d(a^*(t), s(t))$ ,

$$V(t, \{\tilde{a}^*(\cdot), \tilde{s}(\cdot)\}) - d(\tilde{a}^*(t), \tilde{s}(t)) > V_0$$

(for  $\|\tilde{s} - s\|$  and  $\|\tilde{a}^* - a^*\|$  infinitesimal).

2. For all  $t \notin T, t < \sup\{T\}$ ,  $V(t, \{a^*(\cdot), \tilde{s}(\cdot)\}) > V(t, \{a^*(\cdot), s(\cdot)\}) = d(a^*(t), \tilde{s}(t)) + V_0$  (because the future payoff has increased). For infinitesimal  $\|\tilde{a}^* - a^*\|$ , by continuity of the difference,

$$V(t, \{\tilde{a}^*(\cdot), \tilde{s}(\cdot)\}) > d(\tilde{a}^*(t), \tilde{s}(t)) + V_0 > V(t, \{a^*(\cdot), s(\cdot)\}).$$

3. For all  $t \notin T, t > \sup\{T\}$ ,  $\tilde{s}(t) \equiv s(t)$ .  $\tilde{a}^*(t)$  may or may not be different from  $a^*(t)$ . In any event,

$$V(t, \{\tilde{a}^*(\cdot), \tilde{s}(\cdot)\}) \geq V(t, \{a^*(\cdot), s(\cdot)\}) = d(\tilde{a}^*(t), \tilde{s}(t)) + V_0.$$

In all three subsets of the real line, the incentive compatibility constraint (5) is satisfied. Therefore, quasi-equilibrium  $\{\tilde{a}^*(\cdot), \tilde{s}(\cdot)\}$  is full equilibrium. Since  $\tilde{s}(t) > s(t)$  for all  $t \in T$ ,  $\mu(T) > 0$ ,  $V(0, \{\tilde{a}^*(\cdot), \tilde{s}(\cdot)\}) > V(0, \{a^*(\cdot), s(\cdot)\})$ . Therefore,  $\tilde{s}(t)$  yields a better equilibrium. Therefore,  $s(t)$  was not socially optimal. ■

## A.4 Proof of proposition 5

**Proof.** Consider a pair of firms at arbitrary time  $t_0$  deliberating a instantaneous deviation from a path  $s^*(t)$ . Any  $\tilde{s}(t_0)$  above the socially optimal  $s^*(t_0)$  is inconsistent with the

incentives to honor the contract since

$$V(t) = \sum_{\tau=t}^{+\infty} \left( \frac{1}{1+r} \right)^{\tau-t} \left[ \frac{1}{2} F(a^*(\tau), a^*(\tau), s(\tau)) - c(\tau) \right] = d(a^*(t_0), s^*(t_0)) + V_0$$

$$< d(a^*(t_0), \tilde{s}(t_0)) + V_0$$

(by monotonicity of  $d(a, s)$ ). None of the firms agreeing on  $\tilde{s}(t_0)$  would honor the contract. Hence, both firms will renege and share zero surplus at  $t_0$  which is less than  $F(a^*(t_0), a^*(t_0), s^*(t_0))$ .

Choosing any  $\tilde{s}(t_0) < s^*(t_0)$  is similarly suboptimal because  $F(\cdot)$  is increasing in  $s$  and the incentive constraint is satisfied in either case. This proves that  $s^*(t)$  is coalition-proof.

Any path  $s(t)$  exceeding  $s^*(t)$  at a point  $t > 0$  is not an equilibrium by proposition 1. Any degenerate equilibrium ( $T = 0$ ) is not coalition-proof because in all viable quasi-equilibria ( $T = +\infty$ ) output is strictly greater. No viable quasi-equilibrium with  $s(t) < s^*(t)$  on a set of non-zero measure is coalition proof, because payoff can be increased by pairs of firms by agreeing on  $s^*(t)$ . ■

## References

- Akerlof, G. [1980]. A theory of social custom, of which unemployment may be one consequence, *Quarterly Journal of Economics* **94**.
- Arrighetti, A., Bachman, R. and Deakin, S. [1997]. Contract law, social norms and inter-firm cooperation, *Cambridge Journal of Economics* **21**: 171–195.
- Bicchieri, C., Jeffrey, R. and Skyrms, B. [1997]. *The Dynamics of Norms. Studies in Prob-*

- ability, Induction, and Decision Theory*, Cambridge University Press, Cambridge; New York and Melbourne.
- Binmore, K. [1987]. Modeling rational players, *Economics and Philosophy* **3**: 179–214.
- Blanchard, O. and Kremer, M. [1997]. Disorganization, *Quarterly Journal of Economics* **111**.
- Economist staff writer [2000]. Ivan the lethal, *Economist* **354**(8163): 68.
- Ellickson, R. [1991]. *Order Without Law*, Harvard University Press, Cambridge, MA.
- Ghosh, P. and Ray, D. [1996]. Cooperation in community interaction without information flows, *Review of Economic Studies* **63**: 491–519.
- Greif, A. [1993]. Contract enforceability and economic institutions of in early trade: The Maghribi traders' coalition, *American Economic Review* **83**: 525–548.
- Hendley, K., Ickes, B., Murrell, P. and Ryterman, R. [1997]. Observations on the use of law by Russian enterprises, *Post-Soviet Affairs* **19**: 19–41.
- Hendley, K., Murrell, P. and Ryterman, R. [1999]. Law, relationships, and private enforcement: Transactional strategies of russian enterprises, *Technical report*.
- Johnson, S., McMillan, J. and Woodruff, C. [1999]. Contract enforcement in transition, CEPR discussion paper # 2081.
- Johnson, S., McMillan, J. and Woodruff, C. [1999]. Property rights, finance, and entrepreneurship. mimeo.

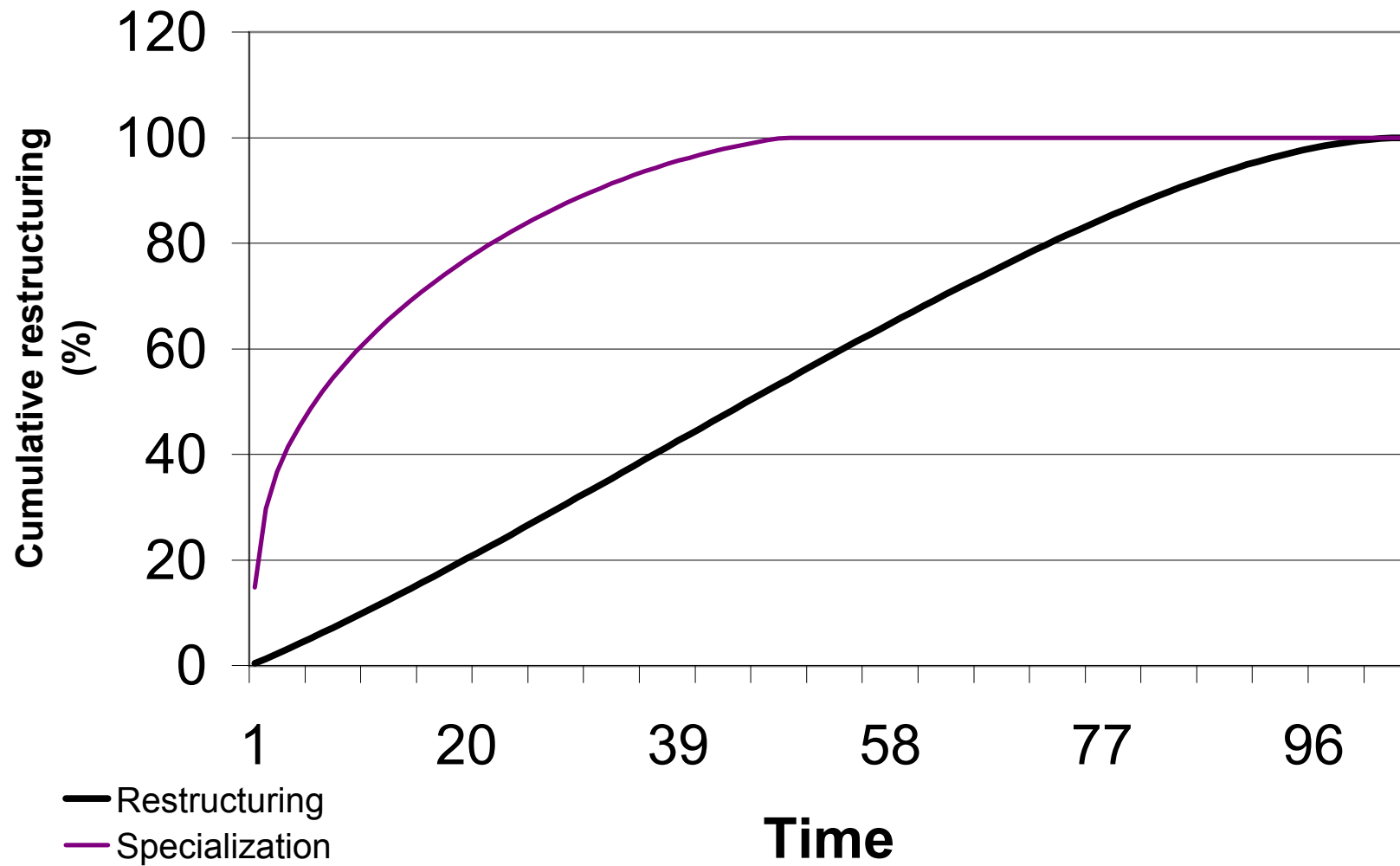
- Johnson, S., McMillan, J. and Woodruff, C. [2000a]. Courts and relational contracts. mimeo.
- Johnson, S., McMillan, J. and Woodruff, C. [2000b]. Entrepreneurs and the ordering of institutional reform: Poland, Slovakia, Romania, Russia, and Ukraine compared, *Economics of Transition* **8**(1): 1–36.
- Kremer, M. [1993]. The o-ring theory of economic development, *Quarterly Journal of Economics* **108**: 551–75.
- Macaulay, S. [1963]. Non-contractual relations in business: A preliminary study, *American Sociological Review* **28**: 55–67.
- McKelvey, R. and Palfrey, T. [1992]. An experimental study of the centipede game, *Econometrica* **60**: 803–836.
- Milgrom, P. and Roberts, J. [1990]. Rationalizability, learning, and equilibrium in games with strategic complementarities, *Econometrica* **58**(6): 1255–78.
- Pistor, K. [1996]. Supply and demand for contract enforcement in Russia: Courts, arbitration, and private enforcement, *Review of Central and East European Law* **22**.
- Rapaczynski, A. [1996]. The roles of the state and the market in establishing property rights, *Journal of Economic Perspectives* **10**(2): 87–103.
- Recanatini, F. and Ryterman, R. [2000]. Disorganization or self-organization?, *Technical report*, World Bank.
- Rosenthal, R. [1981]. Games of perfect information, predatory pricing, and the chain-store paradox, *Journal of Economic Theory* **25**: 92–100.

Rubinstein, A. [1989]. The electronic mail game: Strategic behavior under "almost common knowledge", *American Economic Review* **79**: 385–391.

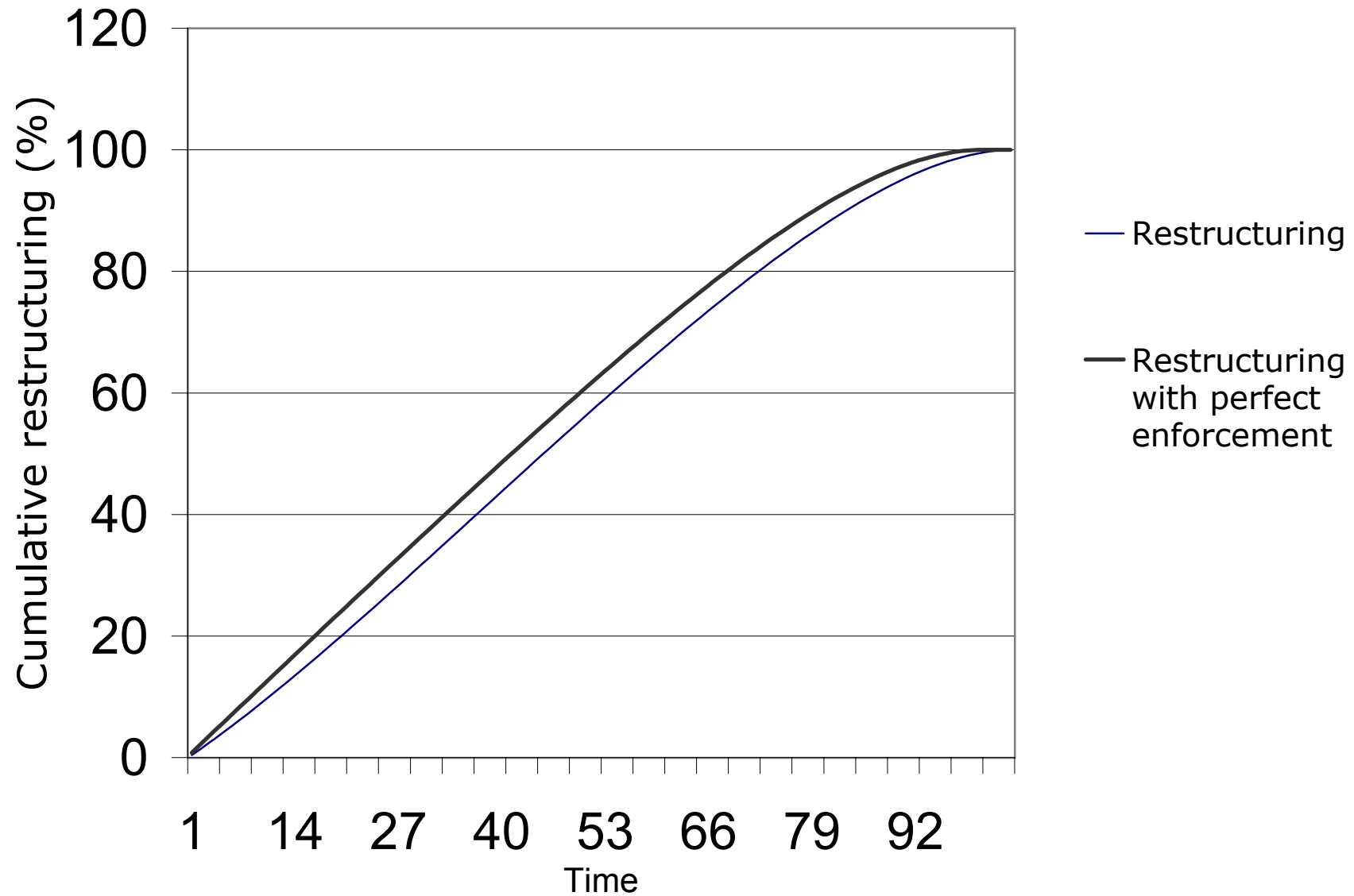
Sonin, C. [1999]. Inequality, property rights protection, and economic growth in transition economies: Theory and Russian evidence. CEPR discussion paper # 2300.



Figure 1. Evolution of restructuring and contract specialization on equilibrium path



**Figure 2. The role of incentive constraint**



**Figure 3.**

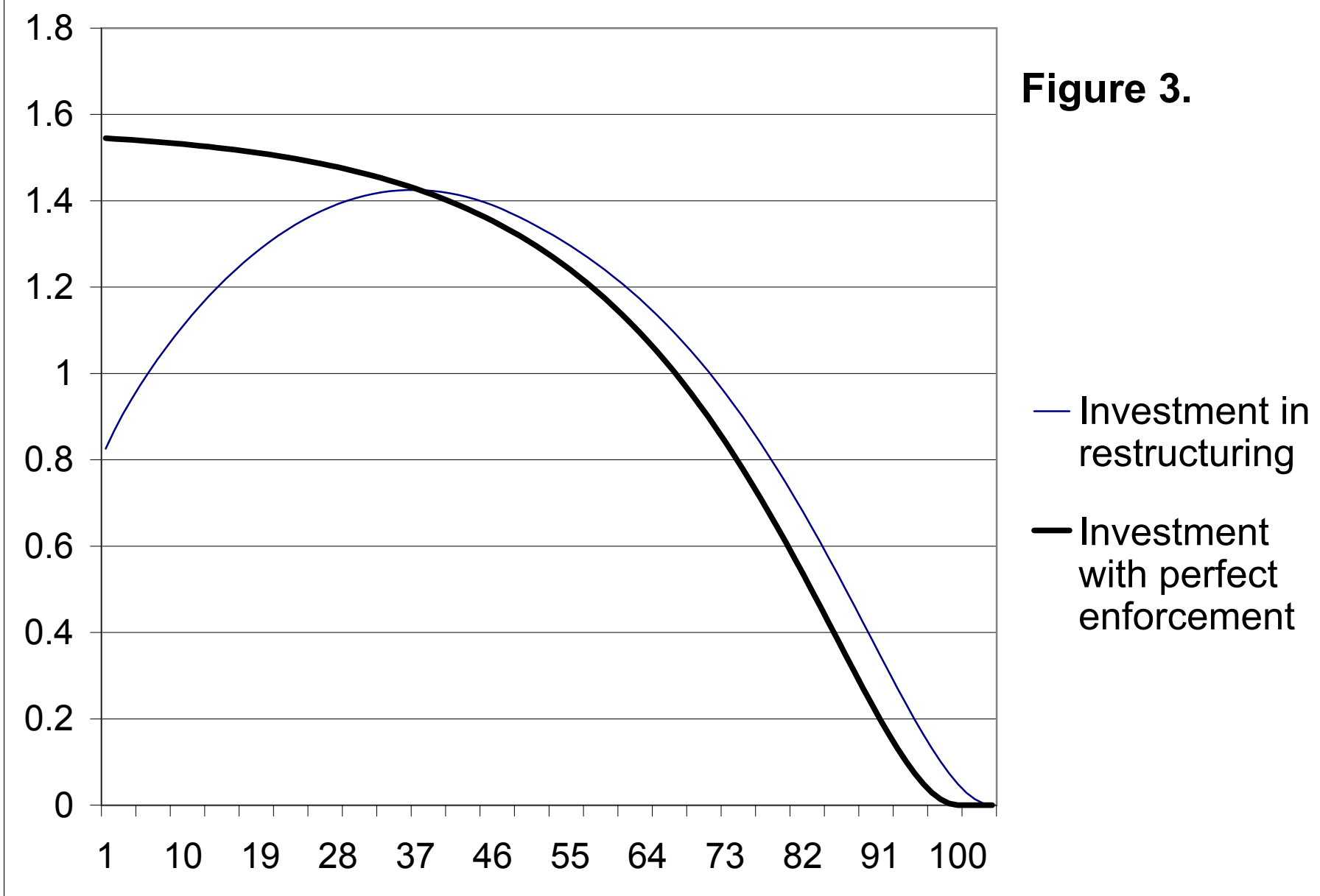


Figure 4. U-shaped specialization path

